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Management of Major Biliary Complications After Laparoscopic Cholecystectomy

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Objective

A total of 50 major bile duct injuries after laparoscopic cholecystectomy were managed by the Duke University Hepatobiliary Service from 1990–1992. The management of these complex cases is reviewed.

Summary Background Data

Laparoscopic cholecystectomy is the preferred method for removing the gallbladder. Bile duct injury is the most feared complication of the new procedure.

Methods

Review of videotapes, pathology, and management of the original operations were reviewed retrospectively, and the injuries categorized. Major biliary injury was defined as a recognized disruption of any part of the major extrahepatic biliary system. Biliary leakage was defined as a clinically significant biliary fistula in the absence of major biliary injury, i.e., with an intact extrahepatic biliary system.

Results

Thirty-eight injuries were major biliary ductal injuries and 12 patients had simple biliary leakage. Twenty-four patients had the classic type injury or some variant of the classic injury. A standard treatment approach was developed which consisted of ERCP for diagnosis, preoperative PTC with the placement of stents, CT drainage immediately after the PTC for drainage of biliary ascites, and usually Roux-en-Y hepaticojejunostomy with placement of O-rings for future biliary access if necessary. Major ductal injuries were high in the biliary system involving multiple ducts in 31 of the 38 patients. Re-operation was required in 5 of the 38 patients with particularly complex problems.

Conclusions

Successful management of bile duct injury after laparoscopic cholecystectomy requires careful understanding of the mechanisms, considerable preoperative assessment by experts, and a multidisciplinary approach.

Laparoscopic cholecystectomy is the preferred method for removing the gallbladder in the United States.[1] As with traditional open cholecystectomy,[2] bile duct injury is the most feared complication related to the new procedure.[3,4] An increased injury rate is associated with a steep learning curve.[5] The learning curve is apparent in both a prospective analysis of laparoscopic cholecystectomy[6] as well as a retrospective analysis of surgeons who have had bile duct injuries.[7]

A series of patients managed with bile duct injuries at Duke University Medical Center has accumulated quickly over the past 2 years. Most of the videotapes of the major injuries were reviewed, allowing us to actually see the injuries take place and also to categorize the types of injury. This report also includes cases of clinically significant bile leakage.

Successful management of the injury really requires a team effort. The hepatobiliary team managing these injuries consists of biliary endoscopists, interventional and CT radiologists, and surgeons.

METHODS

All patients included in this report were managed at least in part at Duke University Medical Center, on the surgical or medical hepatobiliary service or both. All the operative cases were managed by two senior surgeons. Major biliary injury was defined as a recognized disruption of any part of the major extrahepatic biliary system. Biliary leakage was defined as a clinically significant biliary fistula in the absence of major biliary injury, i.e., with an intact extrahepatic biliary system.

This report focuses on the categorization and management of the biliary complications. A previous preliminary report[7] analyzed the experiences of the individual surgeons involved. Details of the experiences of all the surgeons involved in the present report were not available. Therefore, a learning curve analysis is not included.

Other biliary injuries such as retained stones and missed biliary tumors are also not included in this report. During the management of the first dozen major biliary injuries, a standard scheme of management developed for suspected injuries. Although several strictures were managed in a slightly different manner, this approach remained standard throughout the remainder of the study.

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One important consideration in the management of a laparoscopic biliary injury is the possibility of an "excluded" ductal system. An "excluded" ductal system is defined as a segmental or lobar system that does not communicate with the identified ducts. It may be obstructed or fistulized. The usual cause of an excluded system is transection of a low inserting duct while at least one lobar duct remains intact. A severe burn may cause a similar situation. An additional concept in the management of laparoscopic bile duct injury is that most injuries involve a combination of mechanisms such as misidentification of the anatomy, transection, burn, or hepatic arterial injury.

Finally, the true definition of laparoscopic bile duct injury deserves special consideration. Several injuries in this series involved some degree of presumption that the laparoscopic cholecystectomy was the cause of the biliary problem. For example, patients with a biliary stricture appearing weeks or months after surgery could conceivably have other causes of their strictures. Not all the patients had videotapes that proved their injury. One might argue, probably farfetched, despite the temporal relationship in these cases, that the laparoscopic cholecystectomy did not cause the problem but instead there was a preexistent problem or underlying condition. Therefore, it seems necessary to define laparoscopic biliary injury as any biliary disruption identified after laparoscopic cholecystectomy in the absence of an obvious or likely other cause or condition.

A laparoscopic cholecystectomy in turn was defined as any case begun as a laparoscopic cholecystectomy, whether the injury occurred before or after conversion to an open technique. In this series only one patient's injury may have occurred after conversion. This was a 197 kg gentleman who had an understandably difficult attempt at laparoscopic cholecystectomy. The surgeon felt he transected the duct after conversion to an open technique because of misidentification.

RESULTS

A total of 50 laparoscopic cholecystectomy bile duct complications were managed at Duke University Medical Center from 1990–1992. Thirty-eight patients had major ductal injuries and 12 patients had simple biliary leakages. Videotapes were available for review in 21 of the 38 major injuries (55%). Six injuries were managed principally at hospitals outside the Duke system. Those patients received only a small portion of their care at Duke University Medical Center, although advice and/or participation in the surgery at the other hospitals was provided.

Treatment Approach

After the first half dozen cases of severe injury, a standard treatment scheme for patients with suspected injury developed at the medical center (Fig. 1). The vast majority of subsequent patients were treated according to the scheme. Not all the patients received all the tests, however. For example, in some patients, the diagnosis of injury was so obvious that one proceeded directly with PTC. Several patients had operative or percutaneous tubes already placed at the other hospital. Several others with "low" injuries had only endoscopic stents for operative guidance. When an injury is suspected, usually due to pain, liver dysfunction, or fistula, the first intervention was ERCP. The purpose of ERCP is to determine whether an injury was present and to rule out other pathology such as retained stone, leakage, or tumor. The primary ERCP finding in a patient with classic injury is a complete cutoff of the common duct at the level of clips (Fig. 2).

The second intervention is percutaneous transhepatic cholangiography and placement of one or bilateral stents. In the initial six patients, only one stent was placed. Several patients had difficult identification of the contralateral lobar duct at surgery, and several excluded ducts were present. Therefore, the routine became placement of bilateral stents (Fig. 3). In subsequent patients, placement of the contralateral stent revealed excluded segmental ductal systems in four patients that had not been previously identified or suspected.

Immediately after placement of the percutaneous transhepatic stent(s), the patients travel to the computer-

TREATMENT SCHEME

Suspected Injury

↓

ERCP

↓

PTC With Stents

↓

CT Drainage

↓

Roux-en-Y Hepaticojejunostomy

↓

"0" Ring

Figure 1. Multidisciplinary treatment approach for suspected laparoscopic cholecystectomy bile duct injury.

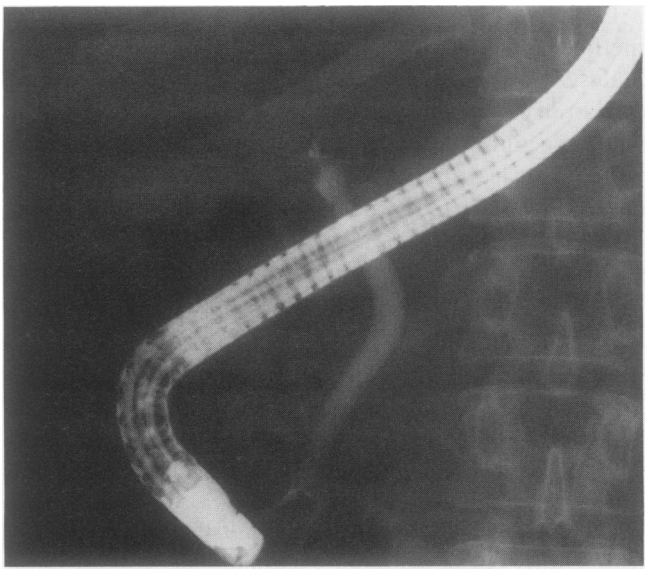

Figure 2. ERCP showing clips at site of common duct complete obstruction.

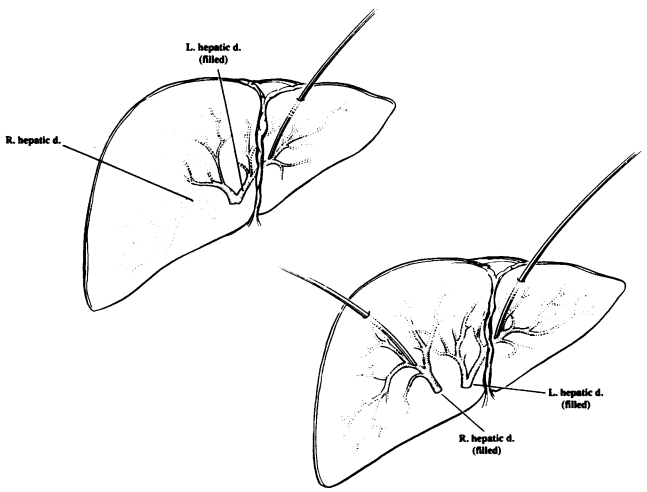

Figure 3. Bilateral stent placement (b) serves for identification of both major ductal systems at surgery and reveals an important ductal system that otherwise could have been missed, in this case the entire right system (a).

ized tomography (CT) suite where CT scan is performed during injection of contrast into a newly placed stent. No oral or intravenous contrast is given. Biliary ascites is drained percutaneously when identified whether loculated or not. Surgery is usually postponed for several days until the patient has defervesced or otherwise stabilized.

The standard operation for major bile duct injury is Roux-en-Y hepaticojejunostomy with separate anastomoses for isolated ducts as necessary. Frequently, several isolated ducts can be sewn together and incorporated into single anastomoses. Following completion of the Roux-en-Y hepaticojejunostomy a horseshoe shaped marker labels the anastomosis and a coronary bypass type "O" ring is sewn to the antimesenteric border of the Roux limb and secured to the peritoneal surface of the anterior abdominal wall (Fig. 4). The purpose of the O ring is for transjejunal biliary intervention in the future, if necessary, because transampullary access is no longer possible and transhepatic puncture is riskier.

A total of 20 preoperative ERCPs were performed at Duke in this series. In four patients, ERCP stents served for identification of the extrahepatic bile duct system at surgery. Twenty-five patients had percutaneous cholangiography, all with stent placement, and 8 patients had preoperative CT drainages of biliary ascites or abscess.

Classic Injuries

Twenty-four patients had the classic type injury or some variant of the classic injury (Fig. 5).7 The classic injury has been described previously. This injury is the most common of laparoscopic major bile duct injuries and caused by misidentification of the common duct for the cystic duct. The common duct is multiply clipped and divided as is a small vessel going to the region of the common duct or the gallbladder. Then, the surgeon, thinking that he has divided the cystic duct, dissects the common duct proximally into the hilum and at some point transects the proximal biliary system. Therefore, the surgeon actually removes a portion of the biliary tree. In addition, the right hepatic artery is usually injured because of its proximity.

Three variants of the classic injury were seen in this series. Two patients had a "common duct—cystic duct" variant.[7] In this injury, the common duct is again misidentified and ligated but the proximal clips are placed correctly on the cystic duct and the gallbladder removed (Fig. 6). Therefore, this injury creates total biliary diversion and fistulization.

A second type variant is a simple tenting injury of the common duct. The cystic duct is correctly identified and grasped, and a portion of the common duct is removed between clips simply due to traction. This variant results in obstruction or fistulization and occurred in two patients in this series.

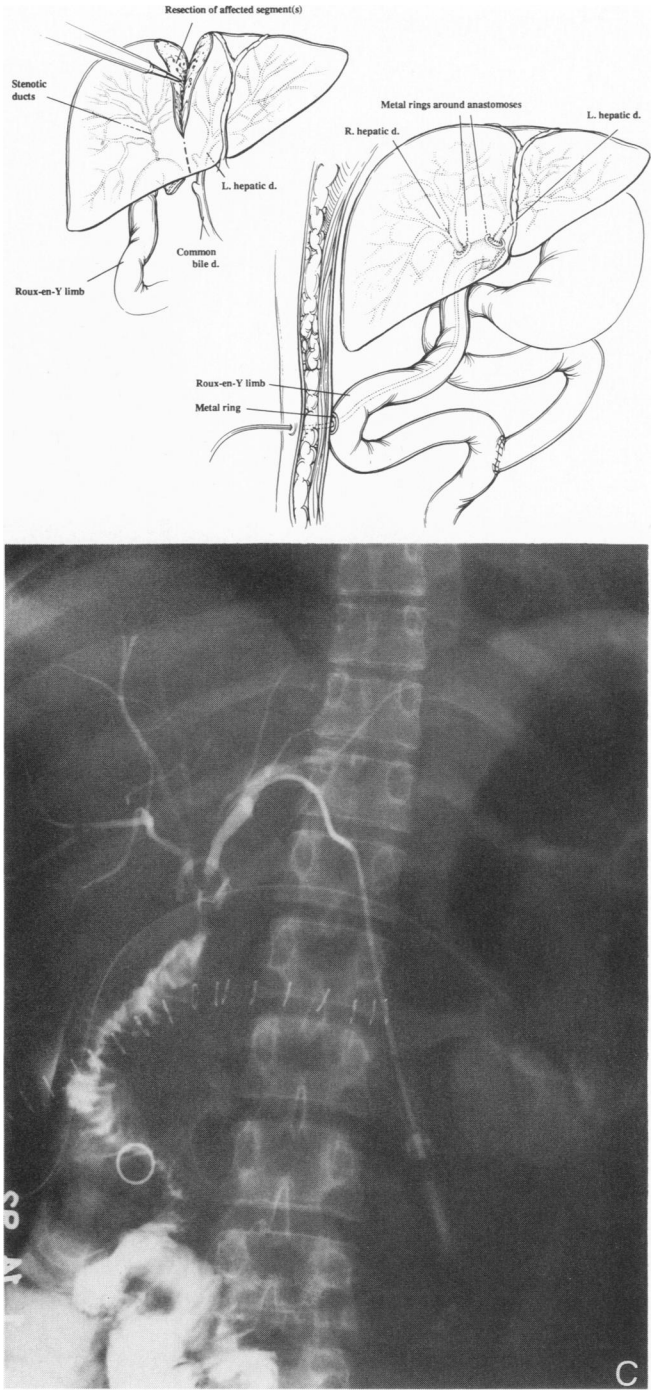

Figure 4. Diagrams showing right hepatic resection for scarred duct after right hepatic duct burn injury and hepaticojejunostomy (a), and attachment of "U" and "O" rings on anastomoses and Roux segment to anteriolateral abdominal wall (b), and postoperative radiograph (c), after affix hepaticojejunostomy.

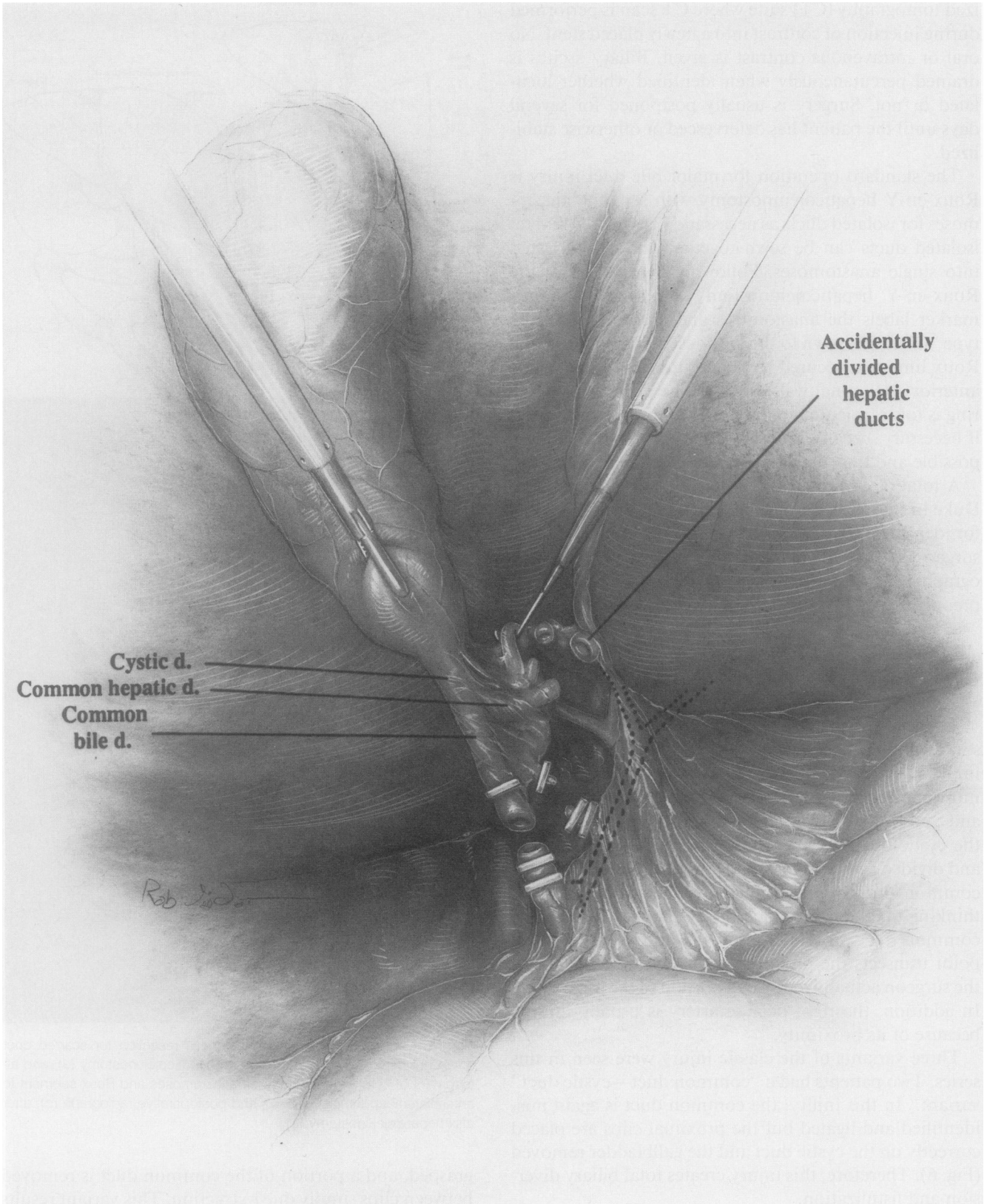

Figure 5. Classic laparoscpic bile duct injury. Portion of extrahepatic biliary tree being removed with three hepatic ducts transected. Right hepatic artery, in background, is also usually injured.

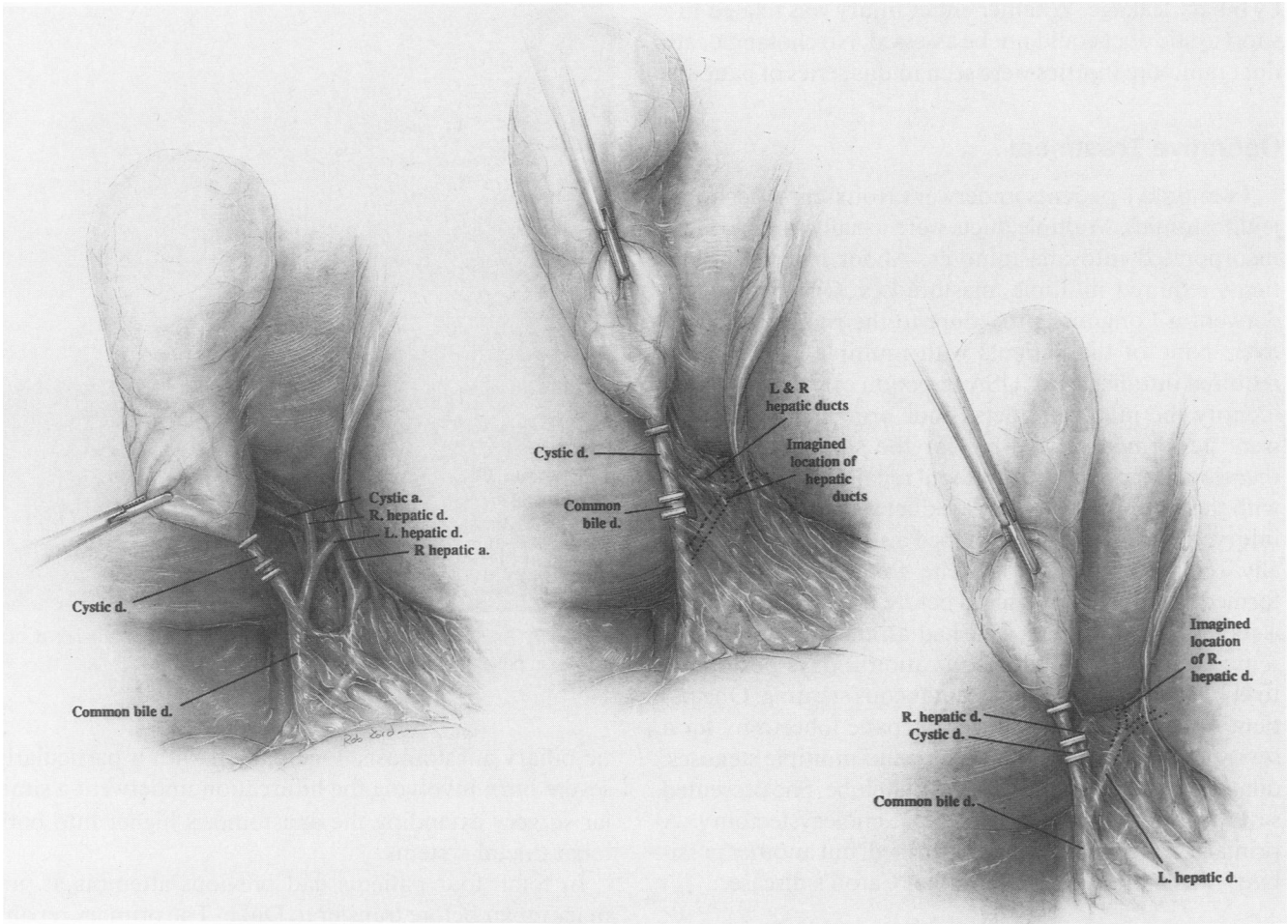

Figure 6. Ideal (a) and nonideal (b and c) dissections for laparoscopic cholecystectomy; (a) shows the preferred placement of clips on the cystic duct; (b) depicts the "common duct—cystic duct" variant of the classic injury; and (c) shows one method by which the right hepatic duct can be injured.

A third variant is an isolated right hepatic ductal injury (Fig. 6). In this variant the right hepatic duct is misidentified as the cystic duct, usually by anterosuperior traction on the gallbladder and posterior dissection. The cystic duct is later divided when it appears like a trivial accessory system. No cases of aberrant anatomy in this series of patients accounted for a right duct or any other injury.

Severity of Injury

The 38 major ductal injuries were high in the biliary system. A small minority (7 patients) had a proximal extent to their injuries no higher than the common hepatic duct. Multiple ducts were involved in 31 of the 38 patients: 8 patients, 2 ducts; 7 patients, 3 ducts; 5 patients, 4 ducts; 6 patients, 5 ducts; and 5 patients, 6 or more ducts. Laparoscopic bile duct injury therefore seems significantly more severe than injuries previously seen after traditional cholecystectomy.

Strictures

Twelve patients had biliary strictures. Symptoms developed 2 weeks to 4 months after laparoscopic cholecystectomy. From videotapes, four strictures seemed related to laser or cautery injuries. The other strictures were similar in appearance and involved primarily the proximal common duct and/or bifurcation. Two strictures involved only the right hepatic duct. Videotapes revealed two general mechanisms of burn injury. One mechanism is a "simple" burn caused by cautery or laser transection of the cystic duct and/or artery and current transmission to the major ductal system. The second mechanism is more complex and consists of overuse of cautery or laser to stop hemorrhage in or near the portal hilum.

Duct Lacerations

Only two patients had simple cautery or scissor lacerations of the common duct. Both injuries were recognized

by biliary leakage. Whether either injury was related to a short cystic duct could not be assessed. No cholangiocath duct puncture injuries were seen in this series of patients.

Operative Treatment

Twenty-five patients underwent Roux-en-Y hepaticojejunostomies. Multiple ducts were usually involved and incorporated into anastomoses. About half of the patients required multiple anastomoses. One patient underwent a Longmire procedure to the right lobe of the liver. Nine of the patients with multiple duct injuries required intrahepatic CUSA resection of parenchyma to identify the involved ducts. Four primary duct repairs were performed. Two were for the simple lacerations mentioned earlier. An additional repair was for a patient with the common duct—cystic duct variant of the classic injury, but this patient developed a stricture and eventually required reoperation. The fourth case was performed at an outside hospital before transfer. It involved a morbidly obese man who had an inadvertent T-tube removal and severe bile fistulization 2 days postoperatively. He was treated by percutaneous stenting. One patient underwent a formal right hepatic lobectomy for a severe right hepatic duct stricture and multiple stenoses, dilatations, and abscesses in the right lobe. She presented several months after laparoscopic cholecystectomy. A primary vascular injury was suspected, but another possibility was a preexistent segmental Caroli's disease.

Reoperation

Five patients underwent reoperation after primary repairs at Duke. One patient had two preoperatively placed transhepatic biliary stents, five separate ducts anastomosed, yet a sixth excluded duct was strongly suspected. On the first postop day, the patient was brought back to the interventional radiology suite where an additional excluded ductal system was identified draining the entire anterior right lobe (Fig. 7). A stent marked this excluded duct for reoperation 4 days later and incorporation of this duct as a sixth anastomosis into the same Roux-en-Y segment. A second patient had a severe burn to the right hepatic duct, and the scarring extended higher into the hepatic radicals over several months. He underwent subsequently a right hepatic resection (Fig. 4). A stricture developed in a patient with the primary repair for the common duct—cystic duct classic injury variant and he underwent hepaticojejunostomy after failure of endoscopic dilatation. Intrahepatic stenosis of a 7th duct causing recurrent cholangitis developed in an additional patient with a six-duct repair. He also underwent preoperative stent identification and an intrahepatic biliary anastomosis. One patient with a particularly severe burn involving the bifurcation underwent a similar surgery extending the anastomosis higher into both lobar ductal systems.

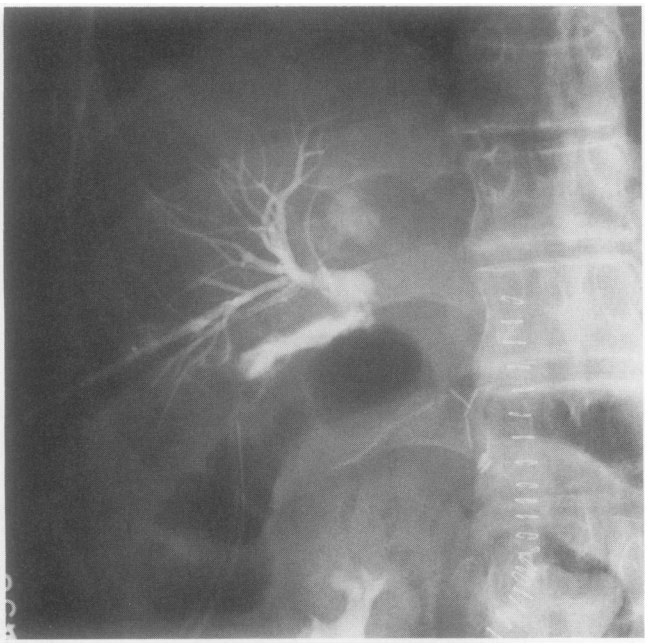

Figure 7. Radiograph of percutaneous identification of anterior ductal system in patient with six-duct injury.

In total, four patients had previous attempts at primary repair before transfer to Duke. The primary repairs of two patients with classic injury were not successful. A fourth patient underwent hepaticojejunostomy that required revision a year later.

One additional patient required a postoperative balloon dilatation approximately 3 months after surgery. Debris rather than stricture, was believed to be the problem. He remains well nearly 2 years after the dilatation.

Endoscopic Treatment

Six patients remain well after dilatation and/or stenting of laparoscopic strictures. We continue to observe these patients closely. Four additional patients underwent attempts at dilatation or stenting but subsequently required hepaticojejunostomy. Ten simple biliary leakages were successfully treated with ERCP stenting or sphincterotomy (Fig. 8). Two patients underwent surgery because of persistent leakage problems greater than 10 days after endoscopic treatment. In both cases of unsuccessful endoscopic treatment of leakage, the site of fistulization was the common duct side of a proximal cystic duct clip. Both patients had cholecystectomies for acute cholecystitis. Therefore, this location suggests

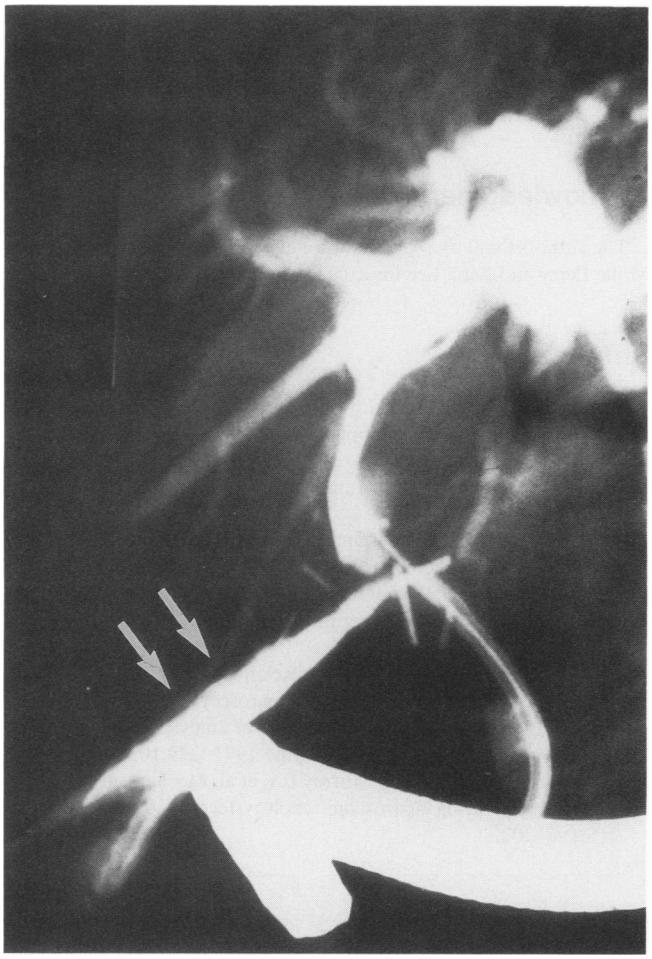

Figure 8. Cystic duct leak treated by endoscopic nasobiliary cannulation. Arrows depict leaks on oblique view.

pressure necrosis by the clips. One patient is not doing well after attempts at endoscopic and percutaneous treatment. She had undergone a primary right ductal repair after conversion at the original operation.

Videotape Review

Preoperative review of all available videotapes was helpful in understanding the mechanisms of injury and planning reoperation. The identification of excessive burning in one case also helped predict postoperative stenosis in one patient. The number of ducts involved in the injury is predictable, and certain principles became obvious for prevention of injury. The most important common denominator of the classic type injury is anterosuperior retraction of the gallbladder infundibulum. This retraction prevents appreciation of the common hepatic duct location and dissection of the cystic duct and artery onto the gallbladder before ligation.

The surgeons can easily be identified as novices or experienced depending on the adequacy of visualization of the operative field. Both novice and experienced surgeons experienced injuries in patients with severe scarring which contributed to misidentification of the operative anatomy.

Significant clues to the possibility of injury that were consistently overlooked include a large "cystic" duct, continued leakage of golden bile during the operation, bleeding from the cut "cystic" duct stump, "accessory" ducts or vascular structures, and the inability to identify a clear tissue plane during the "gallbladder bed" dissection.

Six patients with classic injuries had cholangiography that was interpreted as normal. Five of the six cholangiograms were available for review. Three were normal, and two showed only distal filling. One of the latter two patients also had a small retained stone.

DISCUSSION

Despite its demonstrated overall safety and distinct advantages, laparoscopic cholecystectomy has its own set of complications. Major biliary injuries are more severe than with traditional cholecystectomy[3,4] and requires multidisciplinary expertise for successful results. It may be many years before we see the ultimate fate of these patients with complex multiduct injuries.

Bile duct injury after laparoscopic cholecystectomy can be divided into the following categories: 1) the classic injury; 2) variants of the classic injury; 3) burn injury; and 4) more remediable injuries. Two types of classic injury depend primarily on the surgeon performing the procedure. The first type is the "novice" injury which occurs primarily because of inexperience with the instrumentation and technique. Inexperience results in poor visualization of the operative field and poor exposure, and the above problems. The second type injury occurs when an "experienced" surgeon is adept at using the instruments and familiar with proper methods of visualization, yet still has inadequate exposure. Often considerable acute or chronic inflammation contributes to the lack of exposure.

Even with the injuries of experience, at least those analyzed on videotape, certain principles of dissection are not closely followed. These principles include proper direction of retraction on the gallbladder, prograde dissection (towards the common duct rather than away from it), and overuse of cautery or laser. In addition, early clues that an injury was about to or had just taken place are often overlooked. Therefore, most laparoscopic bile duct injuries seem preventable.

In this series of patients, three variants of the classic injury were seen. The first is the common duct—cystic duct injury. Biliary fistulization through the cystic duct stump is the prominent postoperative sign in this injury.

The second variant is the tenting injury in which a portion of one side or the entire common duct—hepatic duct wall is removed. This likewise presents with fistula or may occur with a complete biliary obstruction, or stricture formation. The third variant is the right hepatic duct injury in which the right hepatic duct rather than the common duct is misidentified as the cystic duct. Aberrant anatomy did not contribute to any injury in the videotape review.

Burn injuries are classified as simple or complex depending upon the reason for the overuse of the energy source. Complex injuries were more severe because of the uncertainty on the part of the surgeon about where the thermal arc was being applied.

The more remediable injuries include simple laceration. Two other types were not seen in this series but have been seen by others,[5] i.e., the short cystic duct and cholangiogram catheter puncture of the common duct.

Cholangiography may have prevented certain injuries in this series but this has not been proven. In fact, three injuries occurred despite the use of cholangiography and proper interpretation. Therefore, cholangiography cannot be relied on as a fail-safe preventive measure, although certainly, appropriate use of cholangiography remains appropriate. Appropriate reasons for advocating routine use of cholangiography include learning the technique, an inexperienced surgeon, or detection of unusual anatomy particularly early in the surgeon's learning experience. Good arguments for selective use of cholangiography remain the experience of the surgeon and the potential for added morbidity or length of the operation.

Appropriate management of bile duct injuries depends upon the available multidisciplinary expertise. If the expertise is not available, patients with such injuries should be transferred to appropriate centers. An experienced biliary endoscopist is important for diagnosis, treatment of retained stones, or simple leakage, and occasionally preoperative stenting and/or attempts at permanent therapy. Preoperative percutaneous stenting is usually important. The need for a skilled interventional radiologist cannot be overemphasized for appropriate identification of the anatomy and the possible multiple sites of injury. An experienced radiologist will also point out possible excluded segments of the liver. An experienced CT radiologist willing to drain biliary ascites contributes a great deal to the management of these patients. Our CT radiologists have also identified numerous other types of unsuspected pathology, such as unusual loculations or abscesses. Certainly, the surgeon has to be experienced in the techniques of repair of small ducts, use of intrahepatic parenchymal resection, and other hepatic resectional techniques. In addition, a protocol for management of these injuries, such as suggested, helps prevent mistakes in diagnosis and treatment.

In conclusion, successful management of bile duct injury after laparoscopic cholecystectomy requires careful understanding of the mechanisms, considerable preoperative assessment by experts, and teamwork.

Acknowledgment

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References

1. National Institution of Health Consensus Development Conference on Gallstones and Laparoscopic Cholecystectomy. Bethesda, Maryland, September, 1992.
2. McSherry CK. Cholecystectomy: the gold standard. Am J Surg 1989; 158:174–178.
3. Cuschieri A, Dubois F, Mouiel J, et al. The European experience with laparoscopic cholecystectomy. Am J Surg 1991; 161:385–387.
4. Rossi RL, Schirmer WJ, Braasch JW, et al. Laparoscopic bile duct injuries: risk factors, recognition, and repair. Arch Surg 1992; 127:596–602.
5. The Southern Surgeons Club, et al. Relationship between physician experience and bile duct injury for laparoscopic cholecystectomy.
6. The Southern Surgeons Club. Prospective analysis of 1518 laparoscopic cholecystectomy. N Engl J Med 1991; 324:1073–1078.
7. Davidoff AM, Pappas TN, Murray EA, et al. Mechanisms of major biliary injury during laparoscopic cholecystectomy. Ann Surg 1992; 215:196–202.

Discussion

DR. E. ARMISTEAD TALMAN (Richmond, Virginia): I would like to congratulate Dr. Meyers on his very vivid and very scary presentation and use this occasion as a plea from chiefs of surgery in community hospitals across this country who are in the trenches of credentialing for the proliferation of laparoscopic procedures. Leaders of American surgery need to address the critical question of which laparoscopic procedures should be currently recommended for the nation's hospitals. Even though documentation of hands-on courses and preceptorship requirements are obviously basic criteria, they are not enough to identify what is appropriate for general application versus what is still unproven and experimental. If we allow the multitude of potential laparoscopic procedures to proliferate without appropriate justification, that is, without documented prospective comparative data then a major disservice will result for countless gullible patients. For instance, what is the justification for abdominal perineal resections and esophagogastrectomies through a laparoscope other than to prove that it can be done, or should such procedures be credentialed for general application? Laparoscopic operations for cancer, colon resections, and nephrectomies, are of particular concern. The College and the major surgical societies and subspecialty societies need to take a stand to identify those laparoscopic procedures that are: 1) currently appropriate based on established data, 2) unproven but reasonable as an option by a competent laparoscopic surgeon, or 3) experimental, still currently contraindi-